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ABSTRACT

Science education has become a focal point in recent years for discussion and speculation. Numerous reports indicate that science instruction is not producing high quality education. This document notes many of the changes in science education by citing historical trends in the field since 1940. It then goes on to describe a cooperative unified science program (for grades K-8 in Springfield, Ohio) known as the Modular Approach to Teaching Science (MATS). It outlines the evolution of the MATS program, including: (1) the appointment of a science coordinator; (2) the development of the experientially based unified science curriculum; and (3) the involvement of various contributors to the program, such as the city school system, science specialists, outside consultants, and federal funding. Evaluative comments about the program are also provided. (TW)

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A SUCCESSFUL SCIENCE PROGRAM:

THROUGH COOPERATIVE AGENCIES EFFORTS

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A SUCCESSFUL SCIENCE PROGRAM:
THROUGH COOPERATIVE AGENCY EFFORTS

Recently, science education has become a spotlight for discussion and speculation. There have been numerous reports indicating that science instruction is not producing high quality education, causing scientists and educators to become alert to this dire situation. To justify the teaching of any subject, educators must examine the contribution to personal development, the ability to foster social responsibility, and the benefits held in increasing the quality of life; all of which the studying of such material might enhance. Hence, a subject should allow the development of cultural profitability. Science, according to this premise, is an accepted subject, but the traditional method of instruction primarily practiced falls short of using the higher reasoning and application skills necessary to guarantee benefit to society. Since science is critical to our economy and this nation's future, the need and demand for science education reform is understandable and necessary. It is time all levels of educational agencies collaborate to produce a unified science educational program.

Historical Path of Science Instruction Since 1940

A review of the developmental path science education has taken will clarify the present position of today's instruction.

The true historical significances began at the close of the 1940's. At the end of this decade, the classical image and ethos of the flux of science changed radically. Science began to determine much of the nation's social, economic and political decision-making processes.

The Sputnik alert in education concentrated attention on science instruction. In the 1960's, students witnessed several projects involving curriculum changes designed to heighten Science education at the elementary level. The learning principles of Jean Piaget, Robert Gagne and Jerome Bruner were central to these projects. The philosophy behind these programs rested on the belief that learners actively construct individual world views based on personal observations and experiences, and that the learners respond to formal instruction in terms of preexisting intuitive perspectives. Furthermore, the new direction of science rested on the premise that events and observations which learners in different populations and cultural groups experience may lead to distinct world views which manifest themselves in diverse responses to science instruction. Teaching correct principles is not sufficient, because young children have deeply ingrained ideas about causality and quantity; and these influence their understanding.

Therefore, the curriculum planners decided that teaching science successfully requires the restructuring of the concepts that the child already possesses, rather than merely supplying "correct" concepts (Linn, 1986 p. 14). This finding set the stage for the following programs designed to promote better science instruction.

Science--A Process Approach (SAPA) designed by the Commission on Science Education (sponsored through the American Association for the Advancement of Science, AAAS) was one such program. The structural base of this program followed a hierarchy developed from Gagne's findings (Victor, 1980). Gagne describes the main goal of SAPA as "not an accumulation of knowledge about any particular domain, such as physics, biology, or chemistry, but competence in the use of processes that are basic to all science." (Gagne, 1966 p. 49).

A second program developed at the University of California, Berkeley, The Science Improvement Study (SCIS) concentrated on the development of scientific literate students. The program integrated Piaget and Bruner's theories. Program leaders introduced concepts, and students applied the conceptual knowledge in "discovery" lessons (Victor, 1980).

The Education Development Center in Newton, Massachusetts originated a third program, The Elementary Science Study (ESS) (1960). The program provided opportunities for students to explore problems that interested them and extended their knowledge, creating insight and enjoyment of the natural and physical world.

The federal government also funded many projects for science materials and equipment from 1958-68 (ERIC Clearinghouse for Science, 1979). However, according to ERIC Clearinghouse for Science, Mathematics and Environmental Education, the government placed restrictions on funding since 1968, causing a reduction in the science materials available for students. As Yager and Penick explain, "the public interest waned in the 1970's, finally climaxing in 1976 with the suspension of all federal funds for science education and a phasing out of all active curriculum development for K-12 sciences" (1987, p. 49).

Toward the closure of the last decade, non-textbook, lab-centered approach programs lost popularity due to three variables. The first problem manifested as the return-to-the-basics syndrome. This was coupled with the second variable, financial difficulties due to troubles within the economy. The third problem, the lack of professional expertise

in science, actualized the demise of lab approaches. Devoid of these variables this innovated science instruction had proven noteworthy. Dyrli (1981) suggested that educators were willing to invest necessary energy to promote student development in information processing skills. He claims that laboratory-centered science instruction is a science teaching approach proven to be "crucial and vital" (Dyrli, 1980).

The 1980's Doldrums. In the 1980's elementary schools, basically speaking, were textbook oriented. The trend to alleviate laboratory-centered science caused many renowned specialists to react. Yager and Penick's (1983) research explains that the investigative or laboratory dimension of science is presently ignored in K-8 classrooms. According to Yager (1984), the primary negative factor in elementary school science centers on the low priority which science is relegated. The explanation of the low status is the return to the basics movement. As Simpson (1983) clearly relates, schools have not treated science as a basic and have not placed science instruction as imperative for national survival as other progress countries have.

Robinson (1985) hypothesizes that perhaps science achievement and attitudes have declined due to the revisitation of

traditional science methodology. Why has this return to traditional science teaching occurred? Time limitation appears to be a major factor. One study found that elementary school children receive an average of two minutes of Science daily (Conant, 1974). However, another answer surfaced in Weiss' study (1978) which identified that the lack of supplies, equipment, funds and materials served as the weakest area. Both of these answers lead to explaining why science instruction returned to the science textbook. The National Education Association describes the science textbook as the largest problem in science education. They view most texts as poor, diluted, bland, disorganized, and sometimes inaccurate. Yager and Penick (1983) support this view of the inferiority of the textbook method explaining that it usually leads to knowledge-based instruction void of hands-on work. It appears that teachers make the textbooks the "answer place" for teacher questions--both those used in discussions and those used in examinations

In the traditional method, audio-visual materials are supplementary to the information given in textbooks and usually repeat the same data. Teachers train students to seek "right" answers in the textbook. The textbook focuses on content and emphasizes words and specialized terminology (Elliott and Carter,

1986). Yager (1983) verifies the importance of terminology in science education, and Brandwein (1981) concludes that most instruction in science centers on the mastery of unique words and terms with little attention given to the real understanding and use of these.

Elliott and Carter (1986) summarize their findings of most popular elementary science textbooks, showing that the texts cover science content but do not promote or encourage the development of scientific thinking or attitudes. Such texts do not engage students in applying the cognitive processes that are basic to understanding the content covered. These authors explain that typically teachers use science texts without drawing on much supplementary resources, thus students understand science mainly as a collection of conclusions to be memorized. Teachers do not adequately teach the nature and methods of science, nor do they provide the opportunity to explore the relationship of science to technology and the problems of the modern world (Elliott and Carter, 1986). They cover both concepts and processes in textbooks as narrative topics. The major goal of the books is to cover topics and to have students carry out cookbook-style activities that have predetermined outcomes. These serve as illustrations not experiences in scientific

inquiry. Thus, the emphasis of the content and the teaching and learning activities of these textbook programs is on the product of science, rather than on the nature and processes of science (the major complaint of Scientific critics). In short, instructors devote little attention toward the pursuit of scientific literacy.

Simpson (1983) cautions that if our public school children receive inept science education in elementary school, they will be unprepared for the abstract thinking necessary in high school Science classes. Thus, they are likely to veto science courses as well as science oriented jobs in the future. Such scientific employment is crucial to the survival of our country. The NEA's article, Quality Education: The State of the Arts (1983-84), advocates that every student should study Science every day, every year, beginning in kindergarten. The association cautions that beginning Science education later is too late; less is too little. So, what is necessary to permanently laying the textbook methods to rest, and provide a clearly successful alternative?

What Is Scientific Literacy? To choose the correct alternative which science education should follow, it is necessary to understand what is meant by science literacy. According to Hurd (1985) the scientific person understands:

(1) basic concepts in science--including a language for communication and key concepts or conceptual schemes, (2) the nature of science, (3) the ethics that control the scientist at work, (4) the interrelationship of science and society, (5) interrelationships between science and the humanities, and (6) the difference between science and technology.

Possible Solutions. A unified laboratory-centered approach is most commonly identified as the solution to this dilemma. Yager, Klien, and McCurdy (1988) explain that hands-on activities in which children manipulate objects, derive relationships, experiment, and draw conclusions, cause science to be the ultimate vehicle for growth and learning in the vital elementary years. Hands-on science, alone, is only a partial answer, though. A collaboratory curriculum, diligently developed is imperative to produce science literate citizens. This requires the various levels of educational agencies to work together.

In 1983, the National Science Teacher Association's project Search for Excellence identified an exemplary science program in Jefferson County, Illinois. The success was attributed to: (1) a careful long-term assessment of students' needs, (2) the creation of activity-oriented curriculum, and (3) extensive teacher training. The staff developed the curriculum from ESS and SCIS.

Dyrli (1981) suggests that educators are willing to invest necessary energy to promote student development in information processing skills. He claims that laboratory-centered science instruction is a teaching approach proven to be crucial and vital (Dyrli, 1980). Recommendations for science instruction improvement include teacher retraining, career incentives for science specialists, and science textbook revision (Elliott and Nagel, 1986). James Rutherford, Chief Education Officer of the American Association for the Advancement of Science, lists several ways and means to improve science instruction. These are: (1) Teachers should not be expected to be science authorities or as a textbook teaching machine, (2) teachers can learn on the job like any other intelligent and dedicated adult, given encouragement, motivation and help, (3) science textbooks should be removed from the elementary school (they promote teacher and student dependency and actually get in the way of good science instruction), (4) a variety of science books should be a readily accessible part of the classroom to be used as a resource only, (5) modern media and technology should be implemented, (6) one or more science and education specialists should be within the classroom reach, and (7) most science work should be done in group activity.

An imperative suggested by Rutherford, Director of the American Association for the Advancement of Science, holds that every teacher should have a science expert available to offer assistance. Yager and Penick (1987) urge college faculty in science to become involved in elementary school science. "Scientists would be most helpful in resolving the crisis if they encourage their most able students to pursue teaching while providing model science teaching themselves. There is much evidence to suggest that the major crisis in science education is the emphasis placed on the singularity of the academic preparation goal; overemphasis of this goal may well be the basis for most of our current problem (p. 54)." It is time for all persons, especially those in the scientific community, to work cooperatively by resolving this real crisis.

This literary review indicates that a program should be developed by the collaboration of all levels of school and curriculum expertise and that the curriculum should be hands-on with books usage limited to referencing. These findings formed the basis for the model science program which follows. The program's goal was to aid elementary teachers in revamping their traditional science program.

THE MATS PROGRAM

The MATS (Modular Approach to Teaching Science) was developed in Springfield, Ohio. This heterogeneous community contains a wide spectrum of socio-economic groups. The elementary population (K-8) consists of approximately 8,500 children. Twenty-six percent (26%) are minorities, 56% of the elementary and 43% of the middle school are categorized as low income, and 22% of the 300 teachers of these children are minorities.

In the fall of 1982, the Springfield City Schools began a study of its elementary and middle school science curriculum by forming a Science Study Committee under the chairmanship of the Assistant Superintendent for Curriculum and Instruction (K-12). The committee consisted of 22 elementary and middle school teachers, administrators and one university science professor. The committee's charge was to evaluate and make recommendations of the K-8 science program. The committee analyzed current science instruction, brought in an expert on K-8 science education, Dr. John Penick from the University of Iowa, visited several exemplary science school programs, and looked at available grade-level equipment.

Study Committee Recommendations

The Science Committee found situations which paralleled those discussed in the literary review. The local problems reflected science education shortcomings nationally. The deficiencies can be categorized into the major problematic areas. First, the teaching of science centered exclusively around textbook teaching in a redundant spiral approach manner. Essentially, the material was taught for several consecutive years, but at an increasingly, more advanced level, each time. Students became bored with studying the same materials. However, a more serious blow to science learning was the students' idea that the study of science was primarily learning vocabulary and facts from a book. Instructors frequently ignored the more important aspects, such as discovery and model-building in their teaching.

The committee approached the first deficiency by developing a revised curriculum. It is evident from this paper's literary review that science instruction must commence at an early age coinciding with the natural curiosity of the child and not after the child has manufactured notions concerning the workings of nature (Resnick, 1983). We can best accomplish this channeling of the natural curiosity by permitting the child direct experiences with phenomenon, i.e. a "hands-on-approach, (Penick

and Yager, 1983). The committee recommended this type of curriculum. Secondly, the committee found that the elementary teachers had minimal understanding of science. This lack of familiarity with scientific concepts and experiments produces an anxiety toward science which often leads to de-emphasis of science teaching, particularly regarding demonstrations and experiments. Even those teachers who were inclined indicated a lack of preparation time and minimal equipment. The committee's recommendation to effectively address this deficiency was to begin teacher training, provide adequate supervision, and increase sufficient science materials. The primary recommendation suggested that the district move from the textbook method to a hands-on approach.

The committee proposed the following three point program to accomplish their recommendations: (1) appointment of a science coordinator, (2) development of a unified science curriculum, utilizing the hands-on approach with corresponding kits (which included all necessary materials and equipment), and (3) provision for training the teachers in the use of the kits, the science involved, and the methods associated with hands-on instruction (see Chart A). The responsibility of the first two points became the district's obligation. Four college professors

THREE POINT PROGRAM

CHART A

SCIENCE COORDINATOR

1. Facilitate curriculum development
2. Organize and distribute boxes
3. Specialist for teachers

DISTRICT

COMMITMENT

TEACHERS

1. All Teachers involvement

MASTER TEACHERS

1. Development of hands-on science curriculum
2. Suggestions for coordinating boxes
3. Demonstrated lesson at summer in-service

CURRICULUM

1. Developed by teachers.
2. Materials purchases
3. Funding available for teachers and materials

interested in science education accomplished the third point by securing a quarter of a million dollar NSF (National Science Foundation) grant. A brief explanation of these three points follows.

Appointment of a Science Coordinator

The local district selected and funded a Science Coordinator. The job description for the position states "the primary responsibility of the Science Supervisor is to ensure the development and maintenance of quality science education. The Science Supervisor will promote continuity in the K-12 science program, functioning as a liaison between the high school science department chairpersons and the elementary and middle school teachers. The basic function is to design, develop, refine, maintain, promote, and supervise an integrated K-12 science curriculum and oversee the direct organization, distribution, and maintenance of science supplies and equipment used in the K-8 program component."

Development of a Unified Science Curriculum

As seen earlier, the hands-on science approach is not new. Since the 1960's, teachers have employed this approach. Two reasons schools hesitate to use this approach are: (1) it is costly, especially when commercial programs are purchased, and (2) often teachers are not prepared to use this approach.

To succeed with a hands-on curriculum, it is necessary that the needed equipment for such experiments is available, time is allocated to assemble and disassemble it, and there is an opportunity to gather disposable supplies. Additionally, the teacher must be familiar with the science topics and the associated materials. The provision of a kit for the experiments solved this problem. Each kit includes every item needed for the topic. Teachers easily can obtain their kits from a central location. The district phased in the kits over a four year period. The NSF team trained teachers from kindergarten, fifth and seventh grades the first year. The team initiated first, sixth and seventh grades the second year. The second, third and fourth grade teachers received training the third year. Special education is the fourth year project.

THE VARIOUS LEVELS OF CONTRIBUTIONS

The City School System

The City School System made a substantial commitment to the science program. The Board of Education appropriated the needed funds for the development of the kits. They also appointed a permanent Science Supervisor, and allocated the funds for the Science kits. The teachers' support for the program is visible through original input in the curriculum committee, inservice summer training, and utilizing and revising the curriculum.

Specialist Input

As noted previously, vital to a strong science program are specialist in science as well as educators. Four college professors elected to collaborate on this project. The two science and two education professors became involved with the program at several levels. The Physics professor, Dr. William Dollhopf participated on the original science committee; therefore, he contributed his expertise from project's commencement. The three other specialists, Dr. Louis Laux (Biology), Dr. Donna J. Cole (Education), and Dr. Linda Buehner (Education) aided in curriculum design.

All four professors met with the curriculum planning committees of various grade levels. During the four year period, the professors consulted with individual teachers as well as the science coordinator. The professors were responsible for the two-week summer in-service as well as in-service training during the academic year.

In-Service Program Description

The in-service program spanned a four year period. (See Table Two.) We completed training of the grades with smaller numbers of teachers in one year, then divided those with larger numbers into two groups and completed these over a two year

COOPERATIVE AGENCY PARTICIPATION

CHART B

AGENCIES	FEDERAL GOVERNMENT	STATE	LOCAL	HIGHER EDUCATION
TASKS	NSF Grant Funding in-service training	advising and consulting	1) Select and support coordinator 2) Teachers and co-ordinator develop curriculum 3) Purchase and replenish materials	1) Involvement in development 2) Provide in-service 3) University labs, rooms, etc.
TIME	Four year Possibility of a 1-2 year supplementary grant	Long-term	Long-term commitment	Teacher in-service training Four year commitment Perhaps a supplementary grant

period. We chose the grade sequence so that a child once introduced into the program, would continue in it.

The course consisted of a two-week, all day segment in August with three in-service days throughout the year. The in-service days during the school year coincided with the completion of one unit and the introduction of the next (as closely as the district calendar would permit). These academic year in-services included early released days in October and December and an all day Saturday session in January. Some grade levels had more in-service days if needed.

Consultants

The NSF team retained four consultants to insure course validity. Dr. John Penick, University of Iowa, evaluated content and structure of the course. Mr. Larry Small, Science Coordinator of a successful Illinois hands-on program, provided guidance with instructional materials and in-service training. Dr. David Finster, Professor of Chemistry and Dr. Robert Morris, Professor of Geology served as consultants and guest lecturers.

Teacher Incentives

All teachers, K-8, are required to participate in this program and received financial compensation for their time.

Observations From Program

Learning science using the "hands-on" approach is just as appropriate for teachers as it is for children. The experience from in-servicing the K-8 district teachers indicates that teachers learn very concretely. They prefer to go through the curriculum day by day, working through easy lessons sequentially. They are not particularly interested in additional background materials and information which they perceive not directly related to their teaching. To address this attitude, we introduced materials from their curriculum early in the two week workshop with more general material presented later. In the first week, teachers concentrated on specific lessons. The education professors, as well as master teachers (those teachers originally on the curriculum planning committee) introduced the teachers to appropriate teaching techniques. Also, there was a short, local field trip relevant to each grade's curriculum, and one general lecture.

At the beginning of the in-service superintendent of schools as well as other administrators spoke in order to clarify their support and dedication to the program and to express their appreciation to the teachers. The greater diversity of activities occurred during the second week of the in-service.

These included four laboratories, one each in biology, chemistry, physics and geology. All teachers participated in these. Throughout the second week several guest speakers presented materials related to the curriculum. Plus the principals of the schools joined the instruction. Each teacher presented one of the lessons to a small group. The Curriculum Supervisor (previously Science Supervisor) was involved constantly. Master teachers were included wherever possible.

There were two major written activities besides evaluations of the workshop. These activities were (1) keeping a daily journal responding to the following questions: What were you most comfortable with today? and What were you least comfortable with today? and (2) Answer any extemporaneous questions which might have arisen today. This activity encouraged the teachers to write and reflect on the workshop activities. All notebooks were read by the staff. Most teachers participated in the preparation of formal and informal evaluations instrumented to be implemented during the coming year.

Evaluation

The utility of the in-services was measured using several different instruments. Due to space restrictions, the instruments and results do not appear here but are available in

the National Science Foundation Annual Report for grant number DPE-8470501. (Dollhopf, 1986 and 1987).

The results of the teacher evaluation instruments indicate that the teachers are gaining new teaching skills and an increased understanding of science. These results show that the program addresses the teachers essential needs for science education. Each year we have modified the inservice training to better address the needs of the teachers. The teachers have responded positively to our approach, and they continue to be pleased with the results.

An attitudinal questionnaire administered to the children who have participated in the program shows a tremendous interest in studying science through MATS. This is a major improvement over the previous year. Many children expressed a willingness to stay after school to participate in science, if hands-on instruction would be used. It is this fact that motivates teachers to continue hands-on science instruction. This is what will keep the program alive in the future, and ultimately insure program success.

In Conclusion

The needed change in science education has to come by combined effort from every level of education. However, teachers

and school districts must take the initiative and claim ownership for program development. They will be the employers of the program. Teachers and curriculum specialists, supported by policy makers, must take the first step. Then educational leaders and science experts must collaborate in the development and implementation, drawing on the best each has to offer.

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